MODBUS REGISTER MAP – SENMA, IRMA

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1. MODBUS COMMUNICATION

Senma, Irma sensors have MODBUS communication protocol implemented to cooperate with industrial PLCs.

1.1. Basic parameters

RTU order form from master to slave	RTU answer from slave to master
TRANSMISSION START Minimum 3.5 x transfer time of one character	**TRANSMISSION START** Minimum 3.5 x transfer time of one character
Recepient ADDRESS 1 byte Value from range 0-240	**Slave device ADDRESS** 1 byte Value from range 0-240
FUNCTION's CODE 1 byte Points at function's code	**FUNCTION's CODE** 1 byte Points at function's code
DATA n x 1 byte	**DATA** n × 1 byte
CRC (checksum) 2 bytes	**DATA** n × 1 byte
TRANSMISSION END Minimum 3.5 x transfer time of one character	**CRC** (checksum) 2 byte
	TRANSMISSION END Minimum 3.5 x transfer time of one character

Maximal length of message (including address and CRC) = 256 bytes (for SENMA sensor = 128 bytes)
Silence longer than 1,5 character clears receive buffer.

1.2. MODBUS data types available in sensor

1.2.1. Coils – single-bit physical outputs (read/write type)

Senma, Irma anticipates and supports Coils, however their change do not have any external outcomes. Coils can be read/written, and they are stored until device is powered off.

Address	Name	Description
#1001	Coil1	for future use
#1002	Coil2	for future use
#1003	Coil3	for future use
#1004	Coil4	for future use
#1005	Coil5	for future use
#1006	Coil6	for future use
#1007	Coil7	for future use
#1008	Coil8	for future use
#1009	Coil9	for future use
#1010	Coil10	for future use
#1011	Coil11	for future use
#1012	Coil12	for future use

#1013	Coil13	for future use
#1014	Coil14	for future use
#1015	Coil15	for future use
#1016	Coil16	for future use

1.2.2. Discrete Inputs – single-bit physical inputs (read only)

Discrete inputs present current bit states of various sensor's components

Address	Name	Description
#2001	Relay1	State of relay #1 (1=high)
#2002	Relay2	State of relay #2 (1=high)
#2003	Relay3	State of relay #3 (1=high)
#2004	Relay4	State of relay #4 (1=high)
#2005	In1	State of digital input #1 (0/1 = Lo/Hi) – sensor is without terminal output
#2006	In2	State of digital input #1 (0/1 = Lo/Hi) – sensor is without terminal output
#2007	In3	State of digital input #1 (0/1 = Lo/Hi) – sensor is without terminal output
#2008	In4	State of digital input #1 (0/1 = Lo/Hi) – sensor is without terminal output
#2009	Valve1	State of valve #1 (ventilation valve) 0 → low (position "measurement") 1 → high (position "ventilation")
#2010	Valve2	State of valve #2 (ventilation valve) – does not exist in SENMA sensor
#2011	PumpOn	State of gas pump: 0/1 = on/off
#2012	PresFlowError	State of flow controller 0/1 = incorrect flow / flow OK
#2013	IsRTC	Presence of RTC clock: 0/1 = not installed / installed
#2014	IsPressFlow	Presence of Flow controller: 0/1 = not installed / installed
#2015	IsPressAbs	Presence of atmospheric pressure sensor: 0/1 = not installed / installed
#2016	IsSwitch	Presence of work knob (manual work mode selector): 0/1 = not installed / installed
#2017	IsHatelDisp	Presence of LED display: 0/1 = not installed / installed
#2018	IsLCD0	Presence of LCD display: 0/1 = not installed / installed
#2019	vacat1	for future use
#2020	vacat2	for future use

1.2.3. Holding registers – two-bytes physical outputs (read/write)

Address	Name	Description
#3001	MBOwnAddress	MSB: own MODBUS address (default 247); LSB: negated address
#3002	FirstZeroingTimeHi	Zeroing moment (clock time), BCD format: 0x00 hh
#3003	FirstZeroingTimeLo	Zeroing moment (clock time), BCD format: mm ss
#3004	WarmingTimeHi	Warming up time (interval), BCD format: 0x00 hh
#3005	WarmingTimeLo	Warming up time (interval), BCD format: mm ss
#3006	CycleTimeHi	Cycle time (interval), BCD format: 0x00 hh

#3007	CycleTimeLo	Cycle time (interval), BCD format: mm ss
#3008	PurgingTimeHi	Ventilation time (interval), BCD format: 0x00 hh
#3009	PurgingTimeLo	Ventilation time (interval), BCD format: mm ss
#3010	MeasureTimeHi	Measurement time (interval), BCD format: 0x00 hh
#3011	MeasureTimeLo	Measurement time (interval), BCD format: 0x00 hh
#3012	ModBusSpecOrder	Special orders – see chapter 1.2.11
#3013	Rs485Mode	RS485 work mode (00AAH = madur, 0055H = modbus, other = modbus)
#3014	PumpPWM	Pump settings: MSB – behaviour during each phase LSB – PWM
#3015	Relay1Hi2Lo	Relay (alarm) threshold value (lower)
#3016	Relay1Lo2Hi	Relay (alarm) threshold value (higher)
#3017	ZeroCalibOrder	Order zeroing/calibration – more information can be found in chapter: 1.2.12
#3018	CalibrationGas	Gas concentration for one-point calibration

1.2.4. Input registers – two-bytes physical inputs (read only)

Address	Name	Description
#4001	MBResult0	measurement result #0 (gas measurement)
#4002	MBResult1	measurement result #1 (measurement of internal temperature)
#4003	MBResult2	measurement result #2 (pressure measurement on flow sensor)
#4004	MBResult3	measurement result #3 (pressure measurement on flow sensor) REMARK: Registers MBResultN returns value -32768 in case of measurement error, or when result is void
#4005	MBResultCode0	result code #0 (see: Table with results' codes)
#4006	MBResultCode1	result code #1 (see: Table with results' codes)
#4007	MBResultCode2	result code #2 (see: Table with results' codes)
#4008	MBResultCode3	result code #3 (see: Table with results' codes)
#4009	MBUnitDP0	unit code (MSB) and number of decimal places (LSB) in result #0
#4010	MBUnitDP1	unit code (MSB) and number of decimal places (LSB) in result #1
#4011	MBUnitDP2	unit code (MSB) and number of decimal places (LSB) in result #2
#4012	MBUnitDP3	unit code (MSB) and number of decimal places (LSB) in result #3
#4013	MBAnaoutU	Voltage at analogue output U in [mV] (does not exist in SENMA)
#4014	MBAnaoutI	Current at analogue output I in [uA]
#4015	MBAnaOutCodeU	result code on analogue output U (does not exist in SENMA)
#4016	MBAnaOutCodeI	result code on analogue output I (see: Table with results' codes)
#4017	MBRTCDateHi	RTC date: 2 bytes in format: BCD – YY YY
#4018	MBRTCDateLo	RTC date: 2 bytes in format: BCD – MM DD
#4019	MBRTCTimeHi	RTC time: 2 bytes in format: BCD – 00 HH
#4020	MBRTCTimeLo	RTC time: 2 bytes in format: BCD – mm SS
#4021	MBStatus	Device status (work phase) (see: Table with work phases)
#4022	MBFirmwareVer	Firmware version: MSB = VersionBig, LSB = VersionSmall*16 + Revision
#4023	MBPhaseTimerHi	Time since the beginning of current phase: 2 bytes in format BCD – 00 HH

#4024	MBPhaseTimerLo	Time since the beginning of current phase: 2 bytes in format BCD – mm SS
#4025	MBSensorRangeMin	Minimum of sensor's measuremnt range
#4026	MBSensorRangeMax	Maximum of sensor's measuremnt range
#4027	MBSensorType0	MSB – type of gas sensor used in device LSB – model of gas sensor used in device
#4028	MBDevice	Device type (see: Table with device types)
#4029	MBSerialNoHi	Serial number (Two MSB bytes)
#4030	MBSerialNoLo	Serial number (Two LSB bytes)
#4031	MBAnaOutUminVoltage	Electrical minimum for output U [mV] (does not exist in SENMA)
#4032	MBAnaOutUmaxVoltage	Electrical maximum for output U [mV] (does not exist in SENMA)
#4033	MBAnaOutImin Current	Electrical minimum for output I [uA]
#4034	MBAnaOutImaxCurrent	Electrical maximum for output I [uA]
#4035	MBAnaOutUMinResult	Result's value that corresponds with electrical minimum of output U (does not exist in SENMA)
#4036	MBAnaOutUMaxResult	Result's value that corresponds with electrical maximum of output U (does not exist in SENMA)
#4037	MBAnaOutIMinResult	Result's value that corresponds with electrical minimum of output I
#4038	MBAnaOutIMaxResult	Result's value that corresponds with electrical maximum of output U
#4039	MBRelay21Src	MSB – trigger source for Relay2, LSB – trigger source for Relay1 (see: Table of trigger sources for relays)
#4040	MBRelay43Src	MSB – trigger source for Relay4, LSB – trigger source for dla Relay3 (see: Table of trigger sources for relays)

1.2.5. Table with device types

Kod	Name	Description
28H	Hatel	madir2015, version Hatel (detector IR single-channel)
29H	SenmaIR	madir2015, version Senma (detector IR single-channel)
2AH	SenmaElch	madir2015, version Senma (detector elchem)
2BH	SenmaO2	madir2015, version Senma (detector O2 elchem)
2CH	SenmaTCD	madir2015, version Senma (detector TCD)
2DH	SenmaVOC	madir2015, version Senma (detector VOC)
2EH	SenmaO2MOX	madir2015, version Senma (detector O2 MOX)

1.2.6. Table of trigger sources for relays

Kod	RelayN behaviour
1	Follow output: AnalogOut I1 ___|‾‾‾
8	Follow the ~In1 → relay is on when In1 Lo
9	Follow the ~In2 → relay is on when In2 Lo
10	Follow the ~In3 → relay is on when In3 Lo
11	Follow the ~In4 → relay is on when In4 Lo

12	Follow the phase → according to byte RelayNBehavior
128+ 1	Follow output AnalogOut I1 with reversed phase ‾‾‾‾|____
128+ 8	Follow the In1 → relay is off when In1 Hi
128+ 9	Follow the In2 → relay is on when In2 Hi
128+10	Follow the In3 → relay is on when In3 Hi
128+11	Follow the In4 → relay is on when In4 Hi
other	Off – relay is permanently turned off

1.2.7. Table with results' codes

Result codes are 2-bytes long

Main code MSB	Supplement code LSB	Type of result	
0	0	O2	volume concentration
1	0	CO2	volume concentration
2	0	CH4	volume concentration
3	0	CO	volume concentration
4	0	NO	volume concentration
5	0	NO2	volume concentration
6	0	NOx	volume concentration
7	0	SO2	volume concentration
8	0	H2S	volume concentration
9	N	X	volume concentration (special gas from Special gases table)
10	N	Y	volume concentration (special gas from Special gases table)
11	N	Z	volume concentration (special gas from Special gases table)
12	0	---	Does not exist
13	0	---	Does not exist
14	0	PumpFlow	Gas flow in sensor's gas channel
15	0	PressAbs	Atmospheric pressure
16	0	PressDif	Differentlial pressure
17	0	Tamb	Ambient temperature
18	0	Tgas	Gas temperature
19	0	T3	Additional temperature #3
20	0	T4	Additional temperature #4
21	0	SL	Stack loss
22	0	Tint	Internal temperature
23	0	Eta	Combustion efficiency
24	0	Lam	Lambda – excess air coefficient
25	0	Flow	Gas linear flow velocity in channel
26	0	Hum	Relative humidity
27	0	CH4mg	mass concentration in STP (standard temperature and pressure)

28	0	COmg	mass concentration in STP (standard temperature and pressure)
29	0	NOmg	mass concentration in STP (standard temperature and pressure)
30	0	NO2mg	mass concentration in STP (standard temperature and pressure)
31	0	NOxmg	mass concentration in STP (standard temperature and pressure)
32	0	SO2mg	mass concentration in STP (standard temperature and pressure)
33	0	H2Smg	mass concentration in STP (standard temperature and pressure)
34	N	Xmg	mass concentration (special gas from Special gases table)
35	N	Ymg	mass concentration (special gas from Special gases table)
36	N	Zmg	mass concentration (special gas from Special gases table)
37	0	---	Does not exist
38	0	---	Does not exist
39	0	UI0	voltage or current on analogue output #1
40	0	UI1	voltage or current on analogue output #2
41	0	UI2	voltage or current on analogue output #3
42	0	UI3	voltage or current on analogue output #4
43	0	UI4	voltage or current on analogue output #5
44	0	UI5	voltage or current on analogue output #6
45	0	UI6	voltage or current on analogue output #7
46	0	UI7	voltage or current on analogue output #8
47	0	Ext1	value measured with external device via analogue input
48	0	Ext2	value measured with external device via analogue input
49	0	---	Does not exist
50	0	---	Does not exist
51	0	CH4rel	relative mass concentration
52	0	COrel	relative mass concentration
53	0	NOrel	relative mass concentration
54	0	NO2rel	relative mass concentration
55	0	NOxrel	relative mass concentration
56	0	SO2rel	relative mass concentration
57	0	H2Srel	relative mass concentration
58	N	Xrel	relative mass concentration (special gas from Special gases table)
59	N	Yrel	relative mass concentration (special gas from Special gases table)
60	N	Zrel	relative mass concentration (special gas from Special gases table)
61	0	---	Does not exist
62	0	---	Does not exist
63	0	MediumPress	Pressure of measured gas
64	x	None	Void result

1.2.8. Special gases table

N	Type of gas	Type of sensor
14	H2 gas	measured with electrochemical cell

15	NH3 gas	measured with electrochemical cell
16	Cl2 gas	measured with electrochemical cell
17	HCl gas	measured with electrochemical cell
32	N2O gas	measured with NDIR sensor
34	CHF3 gas	measured with NDIR sensor
43	VOC gas	measured with PID detector
44	H2 gas	measured with TCD detector
45	HCHO gas	measured with NDIR sensor
46	SF6 gas	measured with NDIR sensor
47	CF4 gas	measured with NDIR sensor
18	BF3 gas	measured with electrochemical cell
19	BCl3 gas	measured with electrochemical cell
50	SiH4 gas	measured with electrochemical cell
51	SiH2Cl2 gas	measured with electrochemical cell

1.2.9. Table with unit codes

N	Unit
0	[ppm]
1	[%]
2	[°C]
3	[°F]
4	[mg/m3]
5	[g/GJ]
6	[hPa]
7	[Pa]
8	[mmH2O]
9	[inH2O]
10	[m/s]
11	[mV]
12	[V]
13	[mA]
14	[A]
15	[ ] - unit-less unit
16	[g/m3]
17	[l/h]

1.2.10. Table with work phases

N	Name	Description
0	FazaWarming	Warming up – initial phase when sensor becomes thermally stable; one-time phase that occurs right after sensor is powered
1	FazaZeroing	Zeroing – performed at the beginning of each measurement cycle;

		calibration of O2 sensor to 20,95% or zeroing of signal of other sensor types
2	FazaMeasuring	Proper measurements executed in each cycle
3	FazaBeforeStandby	Phase before standby phase; during pre-stand-by any gas residues deposited in gas channel are purged
4	FazaStandby	Sensor's resting, device does not perform any measurement but is ready to undertake them at any moment
5	FazaDisplayTest	Initial phase (lasts few seconds after device is powered-on)
6	FazaDisplayIdentification	Initial phase (lasts few seconds after device is powered-on)
7	FazaFirstZeroing	The first zeroing that is performed right after the warming-up phase
8	FazaAfterZeroing	The initial part of measurement phase (infusion of gas and therefore increasing results of measurement) Measurements are on but results are not fully reliable

1.2.11. Register 3012 special orders

Register	Value	Description
3012	0000	NOP (no ModbusOrder order) – does not trigger any action
3012	0001	GoTo Ventilation – restarts measurement cycle and goes to ventilation phase
3012	0002	vacant
3012	0003	GoTo Standby – restarts measurement cycyle and goes to stand-by phase

Order is acknowledged (confirmation of order execution) at MSB byte of ModbusOrder register

Possible acknowledgements (MSB byte of ModBusOrder):

Register	Value	Description
3012	00	Order not yet executed (number of the order remains at the LSB byte)
3012	01	Order executed, positive acknowledgement (number of the order remains at the LSB byte)
3012	02	Order cannot be executed, negative acknowledgement (number of the order remains at the LSB byte)

Incorrect orderes are changed to NOP!

1.2.11.1. Example – forcing sensor to go to ventilation phhase

Algorithm:

1. write value 0x0001 (MOGotoVentilation) to holding register 3012 (register ModbusOrder)
2. read value of holding register 3012 (ModbusOrder)

Read value can be :

- 0x0001 – order has not yet been executed
- 0x0101 – order executed, positive acknowledgement
- 0x0201 – order could not be executed, negative acknowledgement

1.2.12. Zeroing and calibration procedure performed via modbus

Register	Value	Description
3017	0000	Neutral value, being used for erasing the revious value
3017	0001	Order to perform zeroing
3017	0002	Order to erase zeroing
3017	0003	Order to calibrate on a selected gas (gas concentration must be previously entered to register 3018)
3017	0004	Order to restore factory calibration
3017	1001	Positive – zeroing was performed
3017	1002	Positive – erase of zeroing was performed
3017	1003	Positive – calibration on a selected gas was performed
3017	1004	Positive – restoring of the factory calibration was performed
3017	-0001	Negative – could not perfrom zeroing
3017	-0002	Negative – could not erase zeroing
3017	-0003	Negative – could not perform calibration
3017	-0004	Negative – could not restore factory calibration
3018	XXXXX	Integer – concentration of calibration gas in form that is depended on the sensor's resolution (number of decimal places) – see below for more information with examples

Each sensor type used by madur (electrochemical, NDIR, TCD, PID) requires periodical ventilation with neutral gas (usually ambient air) proceeded with zeroing of zero signal.
Irma / Senma sensor is able to perform ventilation procedure automaticaly. It uses three-way valve to swithch to the source of neutral gas (ambient air), after the set time of purging it performs zeroing of zero signal.
It is possible to disable this automatic procedure and call it from external device via modbus

1.2.12.1. Sensor's zeroing procedure:

1. Feed the neutral gas to the sensor for a set time (recommended 15 min) in order to stabilise senor's signal
2. Send zeroing order to register ZeroCalibOrder = 0001 (see table above)
3. Read value from register ZeroCalibOrder to verify if the zeroing procedure was performed correctly (register value should be changed to ZeroCalibOrder = 1001).

Apart from zeroing the sensor, ZeroCalibOrder can be used for:

- removing the zeroing
- perform span calibration
- remove span calibration

1.2.12.2. Span calibration preocedure

1. Span calibration procedure should be preceeded with sensor's zeroing – 1.2.12.1

2. Enter the value of concentration gas to register CalibrationGas. Because register's size is limited to two bytes, the maximal value it can store is 32768. Therefore the correct value for calibration gas depends on sensor's resolution – please see examples below.

Sensor's range	Resolution – numebr of decimal places	Concentration of calibration gas	Value that should be entered to register CalibrationGas
5 %	0,001%	1,24%	1240
5 %	0,01%	1,24%	124
100 %	0,01%	25,5%	2550
20.000 ppm	1 ppm	304 ppm	304
100 ppm	0,1 ppm	50,5 ppm	505

3. Feed the calibration gas to sensor for a set time (minimal recommended: 15 min) in order to stabilise senspr's signal
4. Send calibration order to register ZeroCalibOrder = 0003 (see table above)
5. Read value from register ZeroCalibOrder to verify if the zeroing procedure was performed correctly. (register value should be changed to ZeroCalibOrder = 1003).